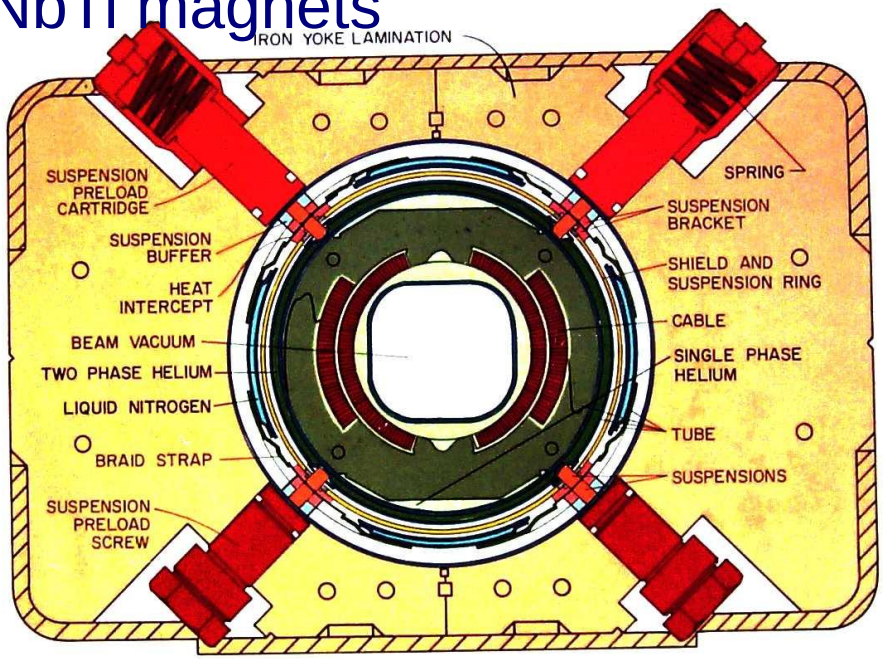
Accelerator Research At Fermilab and UC-ANL-FNAL Collaboration Opportunities

Vladimir Shiltsev
Fermilab

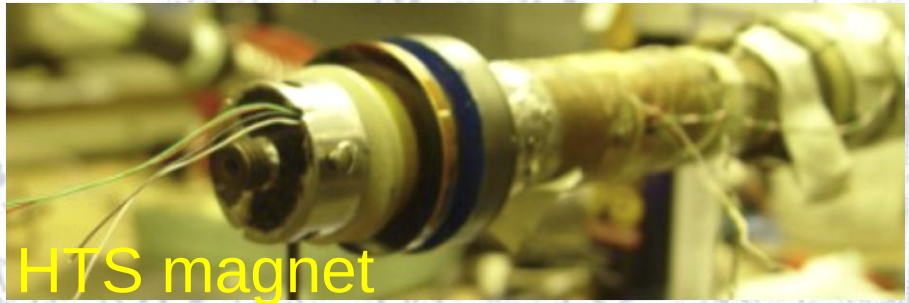
ANL-UC-FNAL Collaboration Meeting
December 7, 2010, Argonne

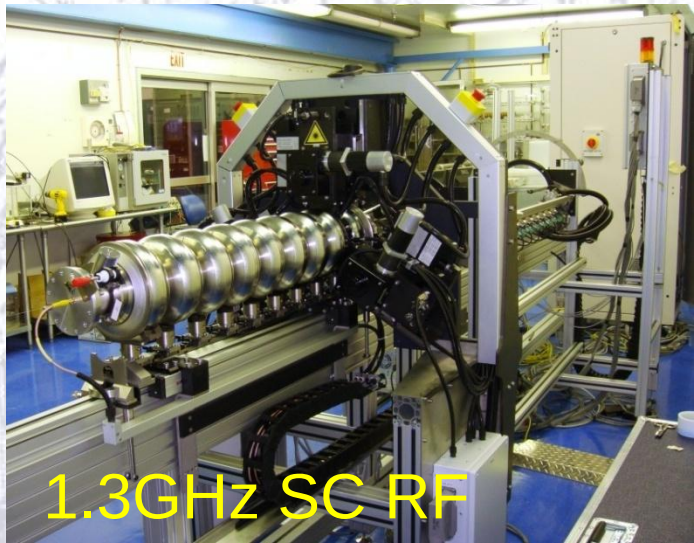
Technology Progress

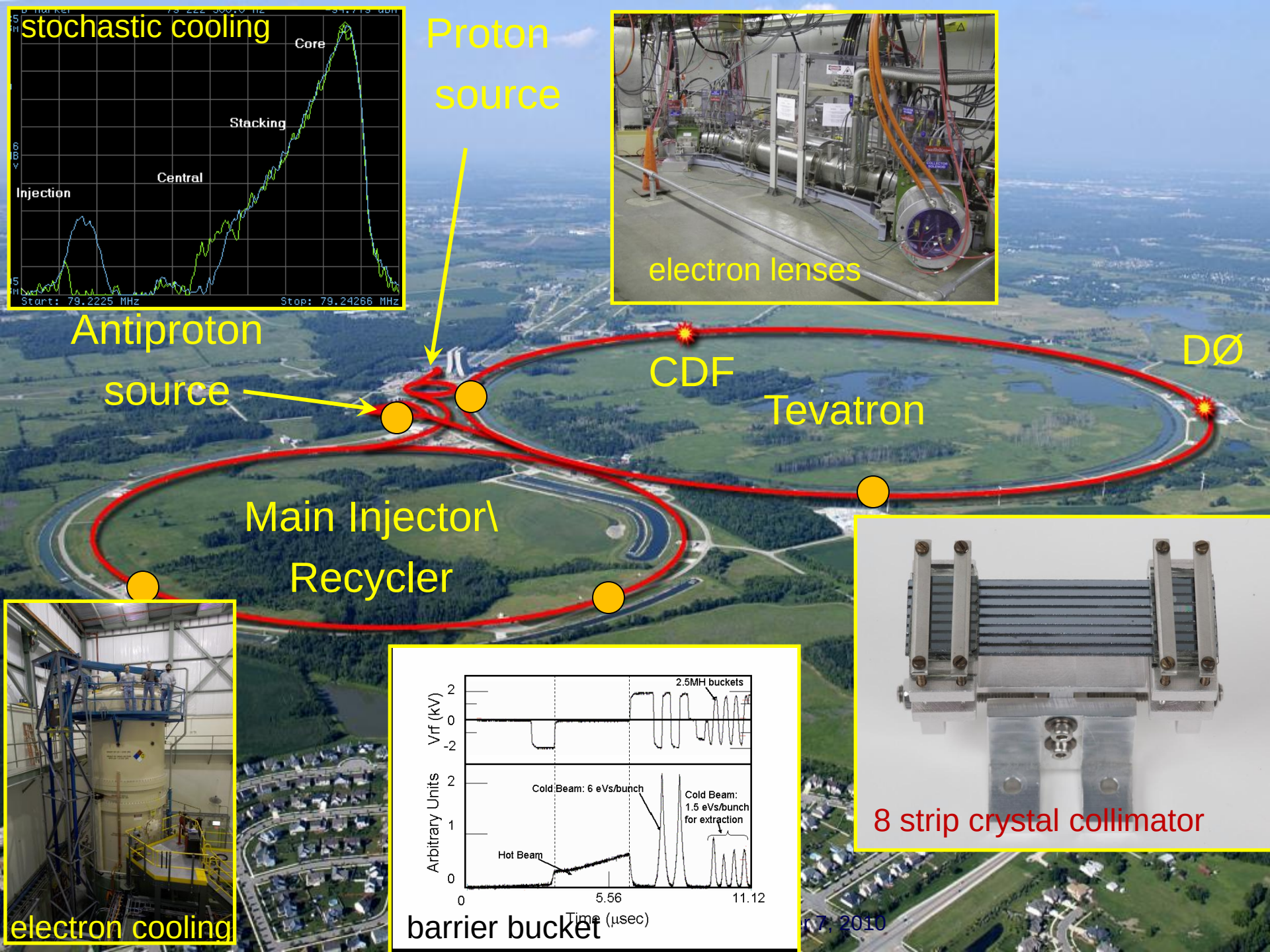
NbTi magnets



Nb3Sn magnet






stochastic cooling
Core
Stacking
Central
Injection
Start: 79.2225 MHz
Stop: 79.24266 MHz
Proton source
electron lenses
Antiproton source
CDF
DØ
Tevatron
Main Injector\ Recycler
8 strip crystal collimator
electron cooling
2.5MH buckets
Vrf (kV)
Arbitrary Units
Cold Beam: 6 eVs/bunch
Cold Beam: 1.5 eVs/bunch for extraction
Hot Beam
Time (μsec)
barrier bucket

Accelerator R&D "Themes"

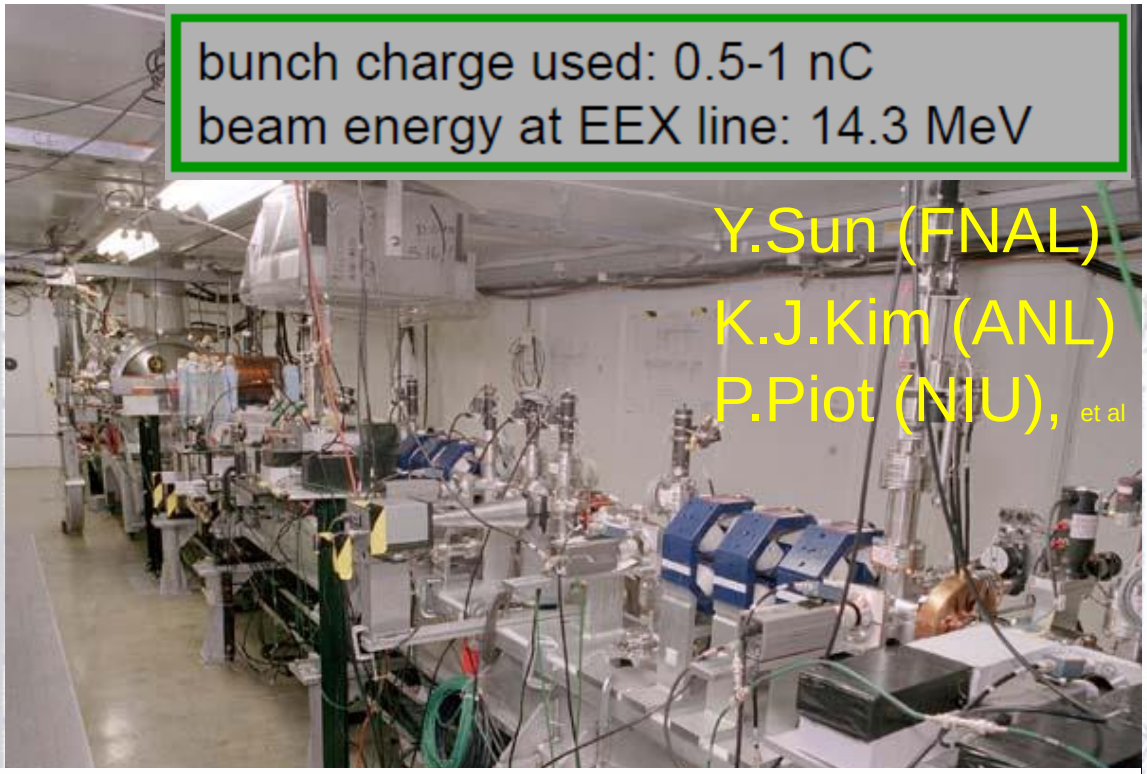
Past and Present (previous slides)

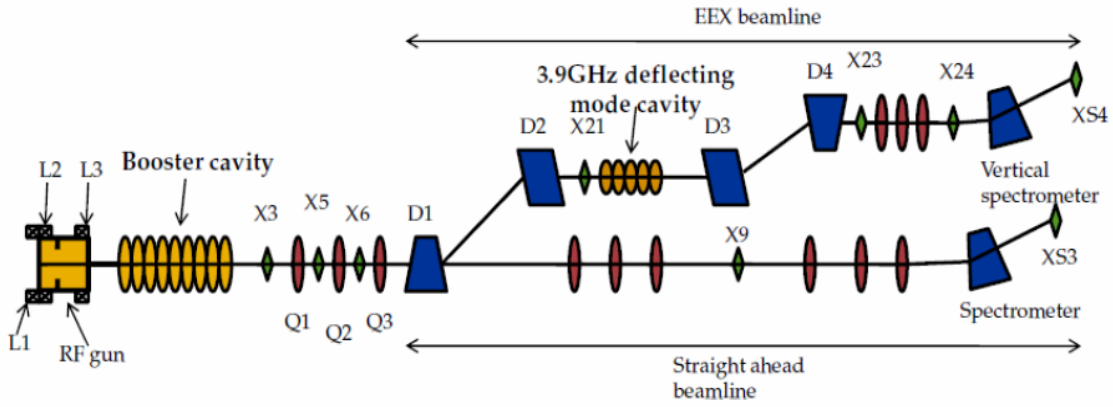
- Technology (magnets and RF)
- Beam manipulations:
  - longitudinal (slip-stacking, RF barrier bucket)
  - transverse (crystal and e-beam collimators)
- Beam Cooling
  - Stochastic and Electron cooling

Present and future R&D (next slides)

- Beam tailoring:
  - Round-to-flat beam transform, transv to long emittance Xchange
- Beam confinement
  - Integrable (stable) beam dynamics ring
- Muon Collider and Ionization cooling

AO Lab: the only place for AARD





Round-to-Flat beam transformation 1:100

Emittance exchange

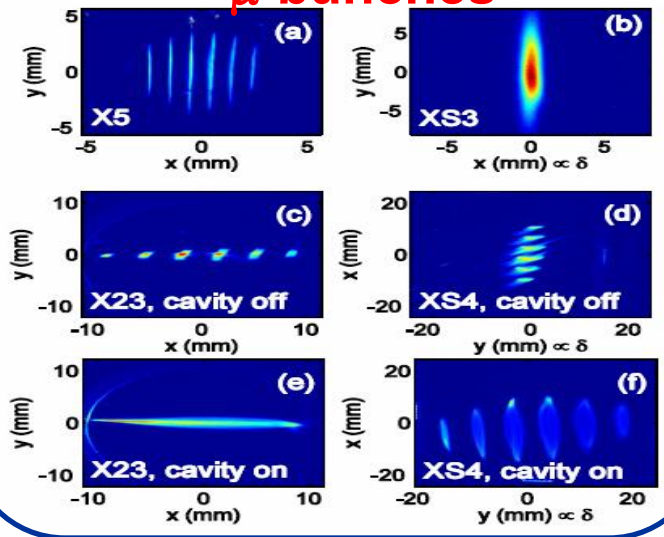
Before EEX → After EEX

$$\varepsilon^{n}{}_{x} = 3 \sim 5\ \mu\text{m} \rightarrow 18\ \mu\text{m}$$

$$\varepsilon^{n}{}_{z} = 21\ \mu\text{m} \rightarrow 7\ \mu\text{m}$$

$$\varepsilon^{n}{}_{y} = 4 \sim 5\ \mu\text{m} \rightarrow 6\ \mu\text{m}$$

μ-bunches



Accelerator Test and Reaserch Facility in New Muon Lab Bldg

NML is being developed as an ILC research and demonstration capability

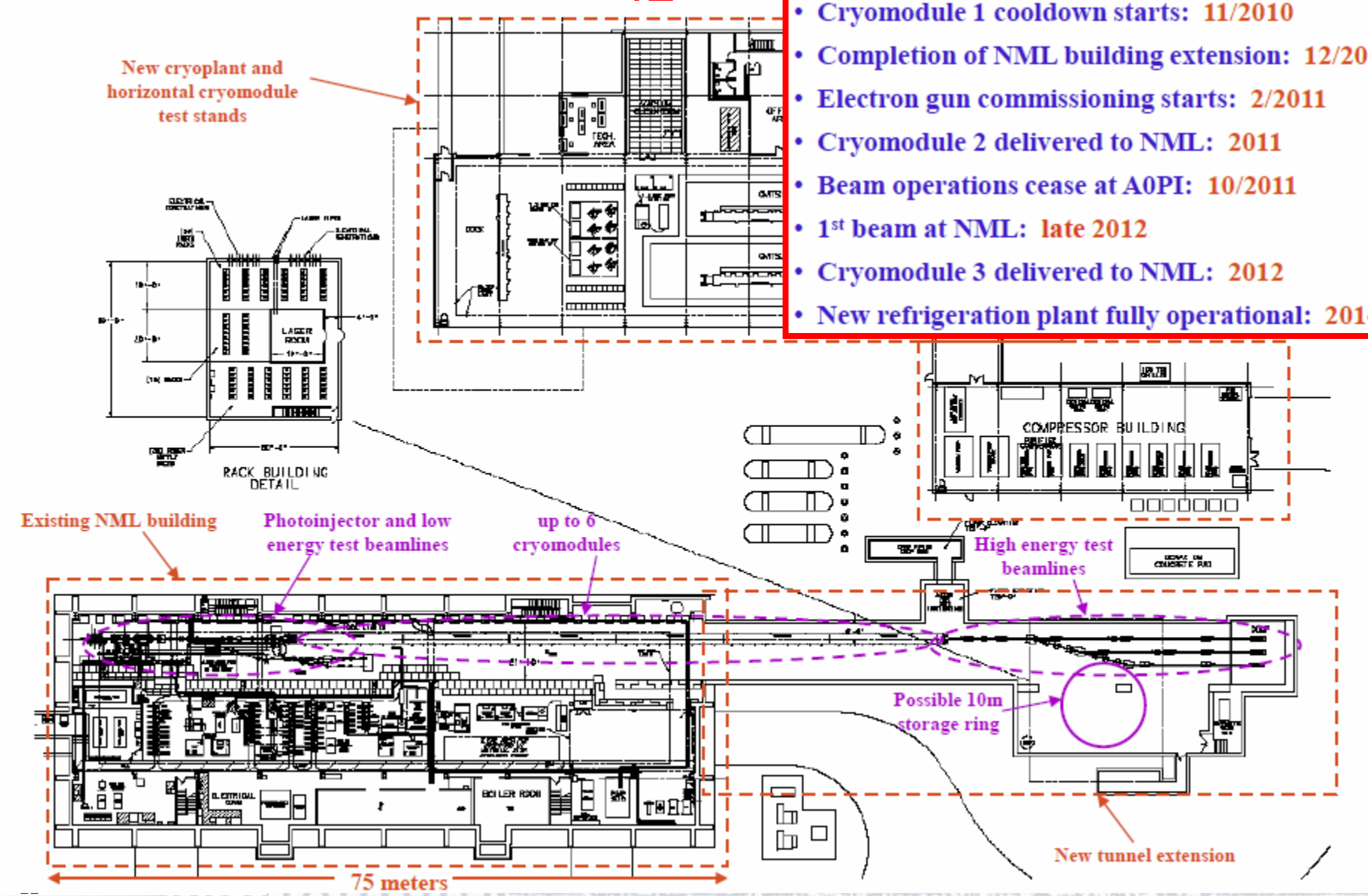
ILC →

Project X

→AARD

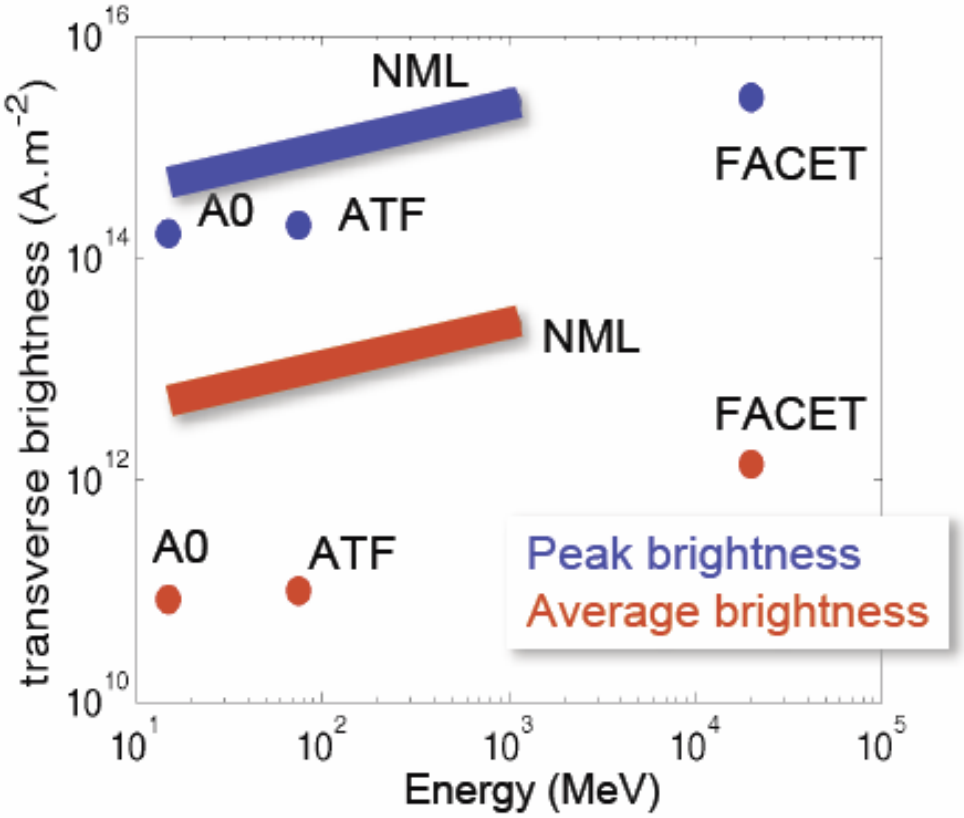
NML Users AARD Facility (plan)

- Cryomodule 1 cooldown starts: 11/2010
- Completion of NML building extension: 12/2010
- Electron gun commissioning starts: 2/2011
- Cryomodule 2 delivered to NML: 2011
- Beam operations cease at A0PI: 10/2011
- 1st beam at NML: late 2012
- Cryomodule 3 delivered to NML: 2012
- New refrigeration plant fully operational: 2014



Uniqueness of the NML

- Variable energy from ~40 MeV (injector beamlines) to ~1 GeV
  1st experiment maybe located in injector at 40 MeV and eventually relocated to the HE line
- High-repetition rate (1-ms trains), dynamical effect in structures (pulse heating, dielectric breakdown, multi-bunch dynamics?)
- L-band SCRF linac
  "large" rf wavelength accommodates drive-witness pulses experiments,
- Photoinjector source
  low phase space volume, easy control of bunch train format (up to 3000)
- Arbitrary emittance partition
  match the beam to the structure size,
- Tailored current profiles,
  enhancement of transformer ratio, drive+witness pulses, super-radiant emission



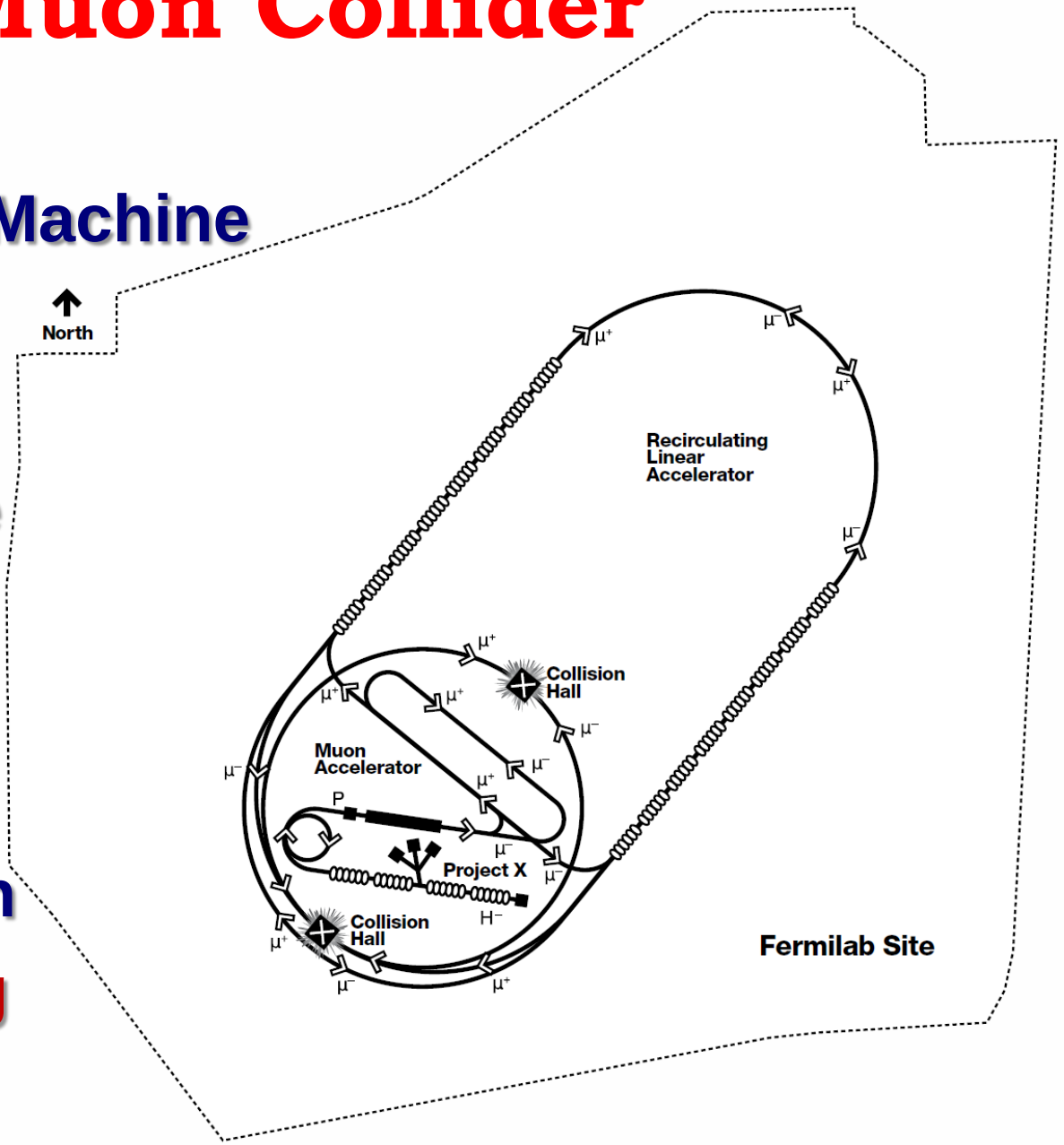
Joint ANL-FNAL "User's Facility" at NML

The idea of jointly ran facility was recently discussed

- Timescale of ~2015 and beyond
- Will greatly expand opportunities for research activities currently conducted at A0/FNAL and AWA/ANL
- Be a real users facility with ANL and FNAL as major stakeholders, and 1st users
  - Nice response to the idea of OHEP providing "stewardship" for national accelerator R&D, i.e. program beyond HEP, incl BES, energy research, etc
- → create a Working Group
  - "….to identify the Scientific Opportunities made available by an Advanced Accelerator R&D (AARD) (AARD) User Program operated at Fermilab's New Muon Lab (NML) facility. " (draft charge from SDH)
  - explore optimum mutually beneficial forms of cooperation between Argonne Fermilab (and UC) in running and using that facility

Muon Collider

- Energy Frontier Machine
  - 4 TeV c.o.m
  - 10^{34} cm-2 s-1
  - fits FNAL site
  - ½ ILC length
  - 1/3 of CLIC
  - clean events
- Requires R&D on
  - muon cooling
  - technology



Fermilab

MAP=Muon Accelerator Program

- **Step #1: set up US Muon Accelerator Program**
  - **DOE review Aug'10**
  - **2011-2016**
  - **11M$/yr → 16M$/yr**
  - **Feasibility Study Report and R&D results**
  - **ANL and UC involved**
- **Step #2: 6D Cooling exp't**
  - **KTeV hall**
  - **2016-2021 → TDR**

"… The proposed work was called very important to the field of high energy physics by the review committee, and the committee found that significant progress had been made by the collaborations."

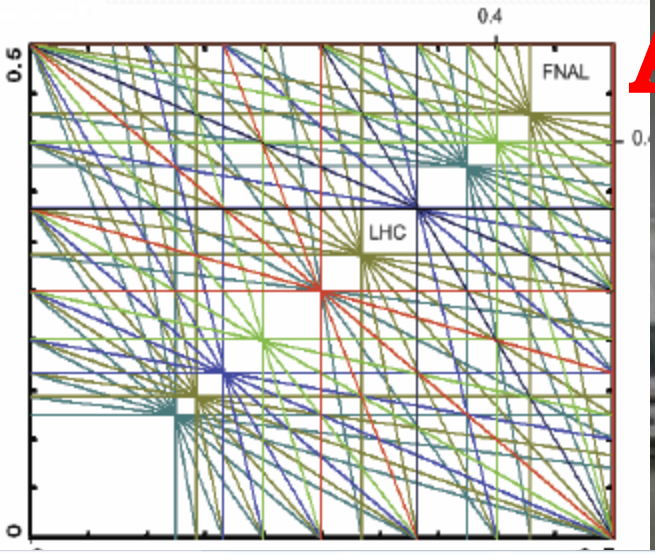
Muon Accelerator Program

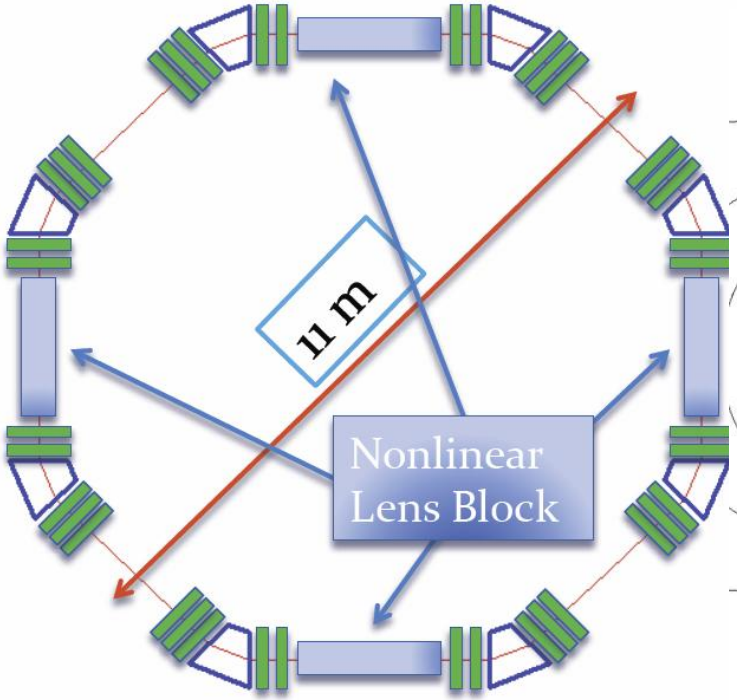
- **University of Chicago:**
  - **Y.K.Kim joined MICE experiment (part of MAP)**
  - **one student (summer)**
  - **one PhD student (cooling simulations)**
- **Argonne:**
  - **involved in MTA RF studies (J.Norem)**
- **Possibilities for Argonne and UC:**
  - **RF breakdown studies/ MICE and design work**
  - **physics and detectors for the Muon Collider and Neutrino Factory (Marcel Demarteau et al)**
  - **machine-detector interface**

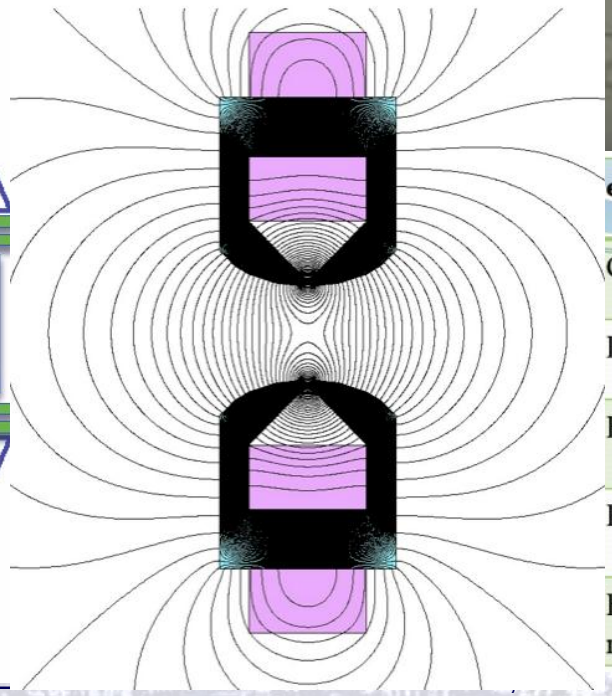
Back up

SLIDES

IOTA = Integrable Optics Test Accelerator



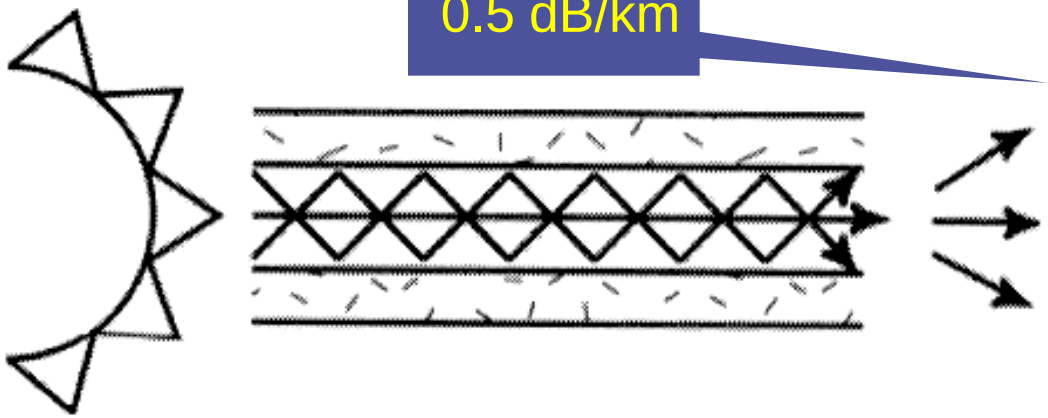


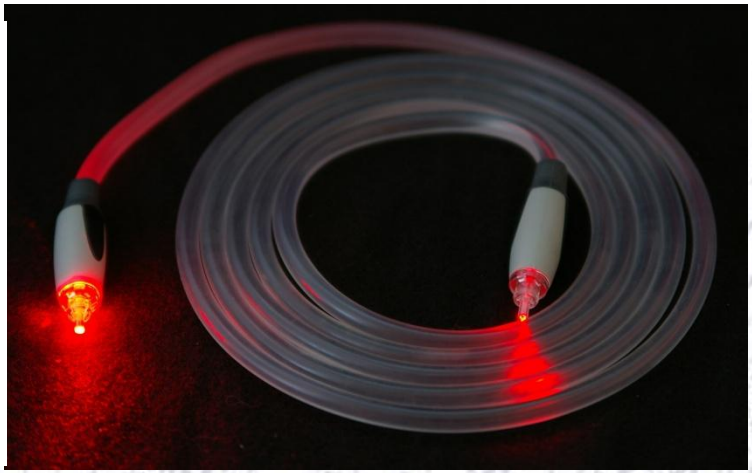


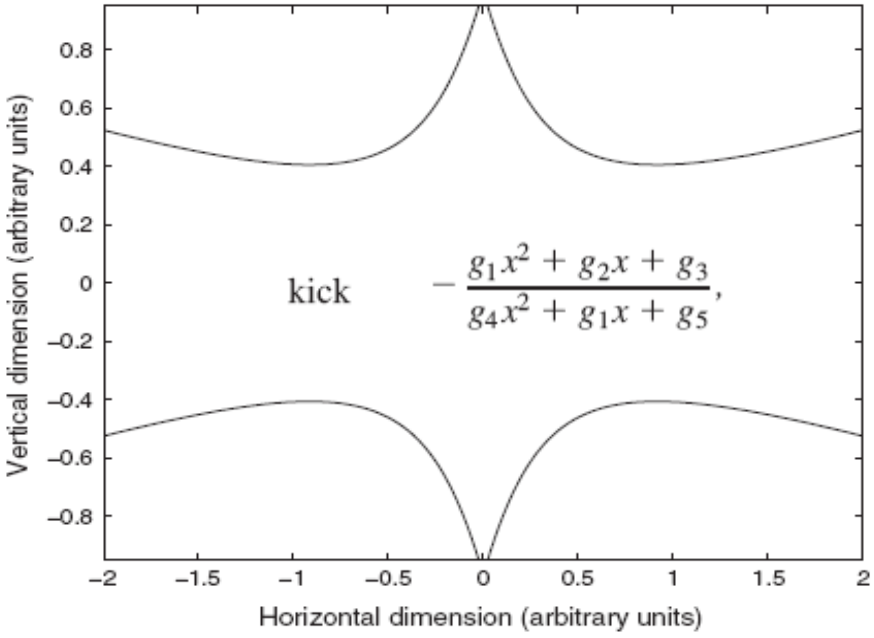
e- Energy	150 MeV
Circumference	32 m
Dipole field	0.5 T
Betatron tunes	Qx=Qy=3.2 (2.4 to 3.6)
Radiation damping time	1-2 s (10^7 turns)
Equilibrium emittance, rms, non-norm	0.06 μm

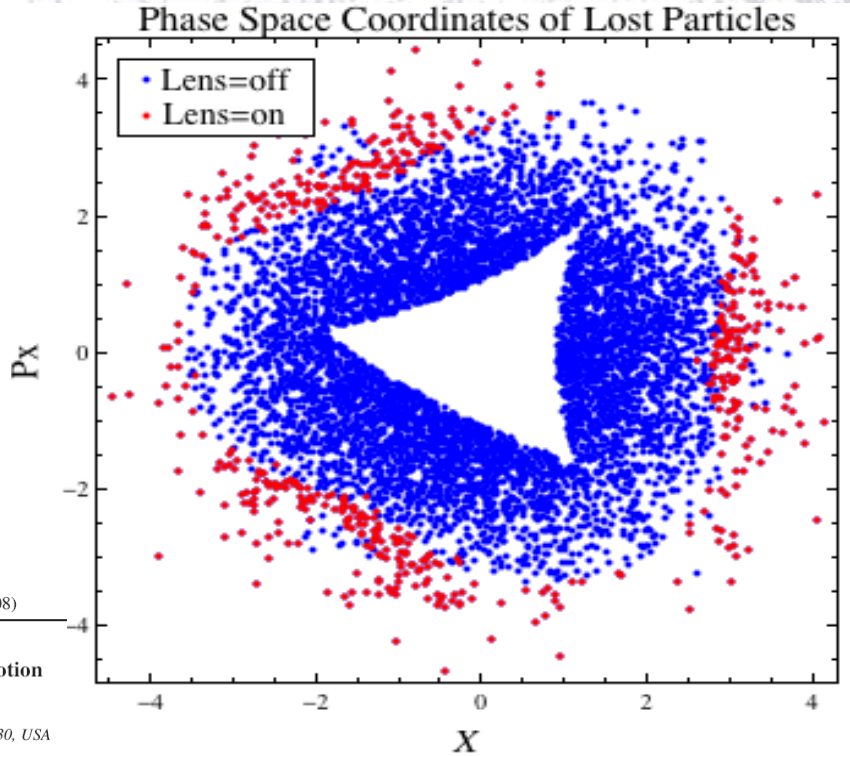
Integrable Beam Optics

0.5 dB/km









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Practical solutions for nonlinear accelerator lattice with stable nearly regular motion

V. Danilov

Spallation Neutron Source Project, Oak Ridge National Laboratory, Building 8600, Oak Ridge, Tennessee 37830, USA

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